Abstracts

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Physical mapping of 5S rDNA loci by direct-clone biotinylated probes in barley chromosomes, K. FUKUI, Y. KAMISUGI and F. SAKAI: *Genome*, **37**, 105–111 (1994).

5S rDNA loci have been mapped on barley chromosomes by in situ hybridization using five reciprocal translocation lines. Two kinds of DNA probes covering either the 5S rDNA coding region or the 5S rDNA coding and flanking noncoding regions were used. They were prepared by direct cloning from interphase nuclei and simultaneous direct labeling in PCR. Four 5S rDNA loci were detected in a haploid genome by the 5S rDNA coding region, whereas in addition, the four or six 5S rDNA related sites, depending on the variety used were revealed by the probe covering the flanking region. The four 5S rDNA loci revealed and mapped on the barley chromosomes.

Endo-1, 4-β-glucanase in suspension-cultured poplar cells, Y. OHMIYA, S. NAKAMURA, F. SAKAI and T. HAYASHI: *Wood Research,* **81**, 5–7 (1994).

An endo-1, 4-β-glucanase was isolated from the cell wall preparations of suspension-cultured poplar cells and its properties were characterized.

Characterization of the adsorption of xyloglucan to cellulose, T. HAYASHI, K. OGAWA and Y. MITSUISHI: *Plant Cell Physiol.,* **35**, 1199–1205 (1994).

The binding of xyloglucan- and cello-oligosaccharides to celluloses can be expressed by Langmuir adsorption isotherms, in which the levels of adsorption maxima are all similar but very low. In the present study, although the adsorption constant increased with incrases in the degree of polymerization (DP) of the 1, 4-β-glucosyl residues of xyloglucan- and cello-oligosaccharides, the adsorption constant of cellopentitol to cellulose was similar to that of hendecosanosaccharide (glucose/xylose, 12 : 9), demonstrating less extensive binding in the case of xyloglucan oligosaccharides in spite of longer chains of 1, 4-β-glucosyl residues. The binding to cellulose of xyloglucans from pea and *Tamarindus indica* can also be expressed as Langmuir adsorption isotherms. The adsorption constant for pea xyloglucan with a DP for 1, 4-β-glucosyl residues of 150 was obviously higher than that for *Tamarindus* xyloglucan with a DP of 3,000. The adsorption maximum and adsorption constant of *Tamarindus* xyloglucan decreased gradually as the DP of 1, 4-β-glucosyl residues decreased from 3,000 to 64. This result demonstrates that fucosylated pea xyloglucan has a higher adsorption constant for cellulose than non-fucosylated *Tamarindus* xyloglucan when the DP of 1, 4-β-glucosyl residues is identical. These findings indicate that xyloglucan binds to cellulose as a mono-layer and fucosyl residues contribute to the increase in adsorption affinity.

Effects of the degree of polymerization on the binding of xyloglucans to cellulose, T. HAYASHI, T. TAKEDA, K. OGAWA and Y. MITSUISHI: *Plant Cell Physiol.,* **35**,

893–899 (1994).

Xyloglucan oligosaccharides were isolated with various degrees of polymerization (DP) and reduced with tritiated sodium borohydride. The ^{3}H-oligosaccharides were tested for their ability to bind to amorphous and microcrystalline celluloses and to cellulose filter paper. The time course of binding indicated that the radiolabeled oligosaccharides continued to be bound for at least 1 h after heating at 120°C. The binding probably required the organization of the oligosaccharides and celluloses by gradual annealing after heating. Although neither pentasaccharide (glucose/xylose, 3 : 2), heptasaccharide (glucose/xylose, 4 : 3) and nonasaccharide (glucose/xylose/galactose/fucose, 4 : 3 : 1 : 1) failed to bind to the celluloses, binding occurred with oligosaccharides with DP equivalent to more than four consecutive 1, 4-β-glucosyl residues. The extent of binding to the celluloses increased gradually from octasaccharide (glucose/xylose, 5 : 3) to hendecosanosaccharide (glucose/xylose, 12 : 9), with the increase in the DP of 1, 4-β-glucosyl residues. The binding of reduced cello-dextrins to cellulose required at least 4 consecutive 1, 4-β-glucosyl residues. The extent of binding of cellopentitol or cellohexitol to cellulose was similar to that of hendecosanosaccharide, showing lower binding for xyloglucan oligosaccharides in spite of longer chains of 1, 4-β-glucosyl residues. These findings suggest that the mode of binding to cellulose of xyloglucan oligosaccharides is different from that of cello-oligosaccharides.

The oligosaccharide units of the xyloglucans in the cell walls of bulbs of onion, garlic and their hybrid, C. OHSUMI and T. HAYASHI: *Plant Cell Physiol.*, **35**, 963–967 (1994).

Xyloglucans were isolated from the 24% KOH-soluble fraction of the cell walls of bulbs of onion *(Allium cepa)*, garlic *(Allium sativum)* and their hybrid. The polysaccharides yielded single peaks upon gel filtration with average moleular weights of 65,000 for onion, 55,000 for garlic and 82,000 for the hybrid. Compositional analysis of the oligosaccharide units after digestion with an endo-1, 4-β-glucanase from *Streptomyces* indicated that the polysaccharides were constructed of four kinds of repeating oligosaccharide unit, namely, a decasaccharide (glucose/xylose/galactose/fucose, 4 : 3 : 2 : 1), a nonasaccharide (glucose/xylose/galactose/fucose, 4 : 3 : 1 : 1), an octasacchride (glucose/xylose/galactose, 4 : 3 : 1), and a heptasaccharide (glucose/xylose, 4 : 3). The xyloglucan from the hybrid contained highly fucosylated units that resembled those from onion rather than from garlic. The analysis also revealed that the xylogucans from *Allium* species contain highly substituted xylosyl residues with fucosyl-galactosyl residues, suggesting that these monocotyledonous plants resemble dicotyledons in the structural features of their xyloglucans.

Compositional analysis of the oligosaccharide units of xyloglucan from suspension-cultured poplar cells, T. HAYASHI and T. TAKEDA: *Biosci. Biotech. Biochem.*,

58, 1707–1708 (1994).

Xyloglucan which was isolated from the walls of suspension-cultured poplar cells showed an average mol wt of 45,000; the extracellular xyloglucan is 25,000 mol wt. Compositional analysis of the oligosaccharide units with *Streptomyces* endo-1, 4-β-glucanase indicated that the polysaccharides were mainly constructed of four kinds of oligosaccharide repeating units, XLFG, XXFG, XXLG, and XXXG. Poplar xyloglucans contain these four units distributed at random, but primarily at the same ratio among their molecules.

Bioscience for men and women, T. HAYASHI: *Nippon Nogeikagaku Kaishi,* **68**, 1435–1436 (1994) (in Japanese).

The review focuses on how to advance bioscinces for Japanese men and women.

A proposed role of oxalic acid in wood decay systems of woodrotting basidiomycetes, M. SHIMADA, D.B. MA, Y. AKAMATSU and T. HATTORI: *FEMS Microbiol. Rev.*, **13**, 285–296 (1994).

The possible roles of oxalic acid, veratryl alcohol, and manganese were investigsted in relation to lignin biodegradation by white-rot badsidiomycetes. Oxalate inhibited lignin peroxidase (LiP) and manganese-peroxidase (MnP), and was decarboxylated by the mediation of veratryl alcohol and Mn. Oxalate was shown to regulate the mineralization of lignin in the vivo system of *Phanerochaete chrysosporium*. In the brown-rot wood decay process, oxalic acid may serve as an catalyst as well as an electron donor for the Fenton reaction, to breakdown cellulose and hemicellulose. Oxaloacetase and glyoxylate oxidase may play a key role in production of oxalic acid by white-rot and *brown-rot* basidiomycetes such as *Phanerochaete chrysosporium, Coriolus versicolor* and *Tyromyces palustris*. A possible role of *oxalate* metabolism is discussed in relation to the physiology of wood-rotting fungi.

Partial purification and characterization of glyoxylate oxidase from the brown-rot basidiomycete *Tyromyces palustris*, Y. AKAMATSU and M. SHIMADA: *Phytochemistry,* **37**, 649–653 (1994).

The glyoxylate oxidase which catalyses oxidation of glyoxyate to form oxalate and H_2O_2 was partially purified from the homogenate of a wood-destroying basidiomycete *Tyromyces palustris* by a combination of $(NH_4)_2SO_4$ precipitation, DEAE-Biogel chromatography and Sephadex G-100 gel filtration. The enzyme purification factor was 60 with 58% recovery. The partially purified enzyme exhibited the pH optimum at about 8. Among the compounds tested, the best substrate was glyoxylate. Glycollate and glycolaldehyde were slightly utilized, but none of the others, such as glyoxal, formaldehyde, acetaldehyde, formate, oxalate, or L-malate was effective. The K_m value for glyoxylate was determined to be 3.7 mM. Enzymatic oxidation was competitively inhibited by oxalate, the K_i value for oxalate was 50 μM. *p*-Chloromercuribenzoate and benzoquinone also strongly

inhibited the enzyme. 2, 6-Dichloroindophenol and potassium ferricyanide served as electron acceptors but neither NAD nor NADP was effective. Neither FMN nor FAD enhanced the enzyme activity. The M_r of the purified enzyme was estimated to be *ca* 127,000 on Sephadex G-100 gel filtration.

Production of oxalic acid by wood-rotting basidiomyctes grown on low and high nitrogen culture media, Y. AKAMATSU and M. SHIMADA: *Material und Organismen,* **28**, 251–264 (1994).

Brown-rot fungi (13 species) and white-rot fungi (11 species) were grown on low and high nitrogen culture media. Changes in the amounts of oxalic acid accumulated by these fungi in the two different culture media were compared, focusing on the metabolism of oxalate in *Serpula lacrynans, Tyromyces palustris,* and *Lentinula edodes.* The results indicate that brown-rot fungi were inclined to accumulate larger quantities of oxalic acid in the low nitrogen medium, as represented by *T. palustris.* The results are discussed in relation to the biochemical role of the oxalate metabolism of fungi growing in nitrogen-poor nutrient environments.

Lignin degrading enzymes, M. SHIMADA: In, "Handbook of Biodegradable Polymers" (ed., Y. Dio) p. 434–443, NTS. Inc. (Tokyo) (1995) (in Japanese).

Characteristics and reaction mechanism of lignin degrading enzymes were described from the aspects of biodegradable polymers.

Synthetic studies of cellulose XII. First chemical synthesis of cellooctaose acetate, T. KAWADA, F. NAKATSUBO, T. UMEZAWA, K. MURAKAMI and T. SAKUNO: *Mokuzai Gakkaishi,* **40**(7), 738–743 (1994).

Cellooctaose derivative **1** synthesized by the linear synthetic method starting from allyl 2, 3, 6-tri-*O*-benzyl-4-*O*-(*p*-methoxybenzyl)-*β*-D-glucopyranoside was converted into cellooctaose acetate **7** by the cleavage of three kinds of protective groups, allyl, *p*-methoxybenzyl and benzyl groups, followed by acetylation. From compound **7**, *α*-D-cellooctaose acetate **8** was prepared by the treatment of acetic anhydride and zinc (II) chloride and crystallization. These compounds were identified by physical and spectroscopic analyses and compared with those of cellooctaose acetate prepared by acetolysis of cellulose. This is the first paper describing the chemical synthesis of cellooctaose acetate.

Findings on wood sample from Khufu's second boat, excavated I. Identification of wood species, T. ITOH, H. SASAKI, S. YOSHIMURA, T. NAKAGAWA, H. SHIRAI, K. HIROTA and H. KUROKOUCHI: *Mokuzai Gakkaishi* **40**, 883–888 (1994).

The main tree species of about 4,600 years old, a wooden boat excavated from beside the Pyramid of Khufu in Giza, Egypt, was identified as one of the genus *Cedrus,* both by light microscopy and scanning electron microscopy. The occurrence of crystals as clusters in the

marginal cells of the rays suggestes that the species may be *Cedrus libani* Loud. or an allied species.

Architecture of the cell wall of a green alga, *Oocystis apiculata*, T. FUJINO and T. ITOH: *Protoplasma,* **180**, 39–48 (1994).

The cell wall of a green alga, *Oocystis apiculata,* was visualized by electron microscopy after preparation of samples by rapid-freezing and deep-etching techniques. The extracellular spaces clearly showed a random network of dense fibrils of approximately 6.4 nm in diameter. The cell wall was composed of three distinct layers: an outer layer with a smooth appearance and many protuberances on its outermost surface; a middle layer with criss-crossed cellulose microfibrils of appfoximately 15–17 nm in diameter; and an inner layer with many pores between anastomosing fibers of 8–10 nm in diameter. Both the outer and the inner layer seemed to be composed of amorphous material. Cross-bridges of approximately 4.2 nm in diameter were visualized between adjacent microfibril by the same techniques. The cross-bridges were easily distinguished from cellulose microfibrils by differences in their dimensions.

The toughness of wood, its structural aspect, T. ITOH: *Wood Research and Technical Notes,* **30**, 16–23 (1994).

Wood is fairly strong compared to its specific gravity. So, wood is well known as strong and light material. This paper deals with the toughness of wood from the structural aspect, that is tissue level, cellular level and ultrastructural level.

Fossil wood of the petrified forest around the Echi River, Shiga Prefecture, T. ITOH: *The Research Report of the Lake Biwa Musetum,* **1**, 33–45 (1993).

The petrified forest of ca. Two million years old was excavated from the base of Echi River, Shiga Prefecture. The fossil wood of 53 specimens was identified microscopically. The taxodiaceae, most probably *Metasequoia* or *Glyptostrobus,* and *Alnus* sp. were abundant.

The wood remains excavated from Awazu Site at the bottom of the Lake Biwa, T. ITOH: *Research Bulletin of the Shiga Prefectural Association of Cultural Properties,* **6**, 1–13 (1993).

The wood remains that are traced back to Johmon era were excavated from Awazu Site at the bottom of the Lake Biwa. The wood remains of 100 pieces were identified microscopically. The most abundant species was *Quercus* sp. sect Cerris with 26 out of 100. The other identified species are *Alnus* sp. with 8 out of 100, *Fraxinus* sp. with 6 out of 100, *Cleyera japonica* with 5 out of 100, *Salix* sp. with 4 out of 100, *Callicarpa japonica* with 4 out of 100. The other 25 species were also identified.

Tree species of excavated wood, In "The Aso-4 pyroclastic flow with buried forest in Saga Plain", T. ITOH and T. MITSUTANI: *The Excavational Reports of Yato Site in the*

Fiscal Year of 1993, The Board of Education, Kamimine Town, 58–68 (1994).

The buried forest was excavated in the underground of Yatoh Site in Kamimine Town, Saga Prefecture. The forest was buried by Aso-4 pyroclastic flow formed by the eruption of Mt. Aso., which is traced back to 80,000 years old. The wood samples of 173 was identified microscopically. More than half of then, that is 89 pieces, belonged to *Picea* sp. Thirty six out of eighty nine was *Picea maximowiczii.* The most abundant species of broadleaf tree was *Fagus* sp. with 15 pieces, the second most species; *Quercus* sp. sect Prinus with 12 pieces, the third most species; *Acer* sp. with 9 pieces. Based on the tree species and its frequency of excavation, the environment of buried forest was thought to belong to subarctic zone.

The site of the formation of wood cell wall, T. ITOH: *In, "The hundred information of wood", The Association of Japan Forst Engineering,* 58–59 (1995).

The structure and formation of wood cell wall is explained briefly.

The structure and function of plant cell and cellulose microfibril, T. ITOH: *The Molecular Biology of wood, T. Higuchi, ed., Buneido press,* **17–28**, 102–108 (1994).

The cytoskeleton, plasma membrane and cell wall is explained as part of the textbook for the molecular biology of wood. The biogenesis of cellulose microfibril is also explained.

Direct imaging of polysaccharide aggregetes in frozen aqueous suspension, J. SUGIYAMA, C. ROCHA, T. TURQUOI, F. TRAVEL and H. CHANZY: *Carbohydr. Polym.,* **23**, 261–264 (1994).

The frozen-hydrated/cryo-transmission electron microscopy technique has been used to observe polysaccharide aggregates in vitreous ice. Images of Kappa-carrageenan in the helical state showed fairly large aggregates of a loosely intertwined network of thin rigid rods. Aggregates of agarose in the helical conformation were also visualised. In comparison with those of Kappa-carrageenan, the strands of agarose were shorter and less rigid. This difference is discussed in terms of the current knowledge of the gelation of these polysaccharides.

Fine structure and tensile properties of ramie fibers in the crystalline form of cellulose I, II, III_I, A. ISHIKAWA, J. SUGIYAMA and T, OKANO: *Wood Research,* No. **80**, 16–18 (1994).

A preliminary result on the mechanical properties of ramie cellulose polymorphs was presented. In general, all polymorphs did not show signidicant change in appearance but exhibited different tensile behavior caused by alternation in the fine structure.

Space group of highly crystalline α chitin in the grasping spines from arrow worms (*Sagitta* spp.), Y. SAITO, J. SUGIYAMA and T. OKANO: *Wood Research,* No. **80**, 19–21 (1994).

The space group of α chitin was investigated by means of X-ray and electron crystallography. After thorough investigation, the space group was found to be $P2_12_12_1$, which required the antiparallel arrangement of the adjacent chitin chains.

Two crystalline phase (I_α/I_β) system of native cellulose in relation to plant phylogenesis, M. WADA, J. SUGIYAMA and T. OKANO: *Mokuzai Gakkaishi,* **41**, 186–192 (1995).

The classification of native celluloses of varioous origins ranging from algae to seed bearers in terms of the two crystalline phase system was conducted with particular reference to plant phylogenetic order. Statistical analysis indicated close correlations between structure and phylogenic order and predictred that a boundary line of phylogenesis between algal-bacterial type and cotton-ramie type existed in Chlorophyta.

Stuructral diversity of native celluloses, J. SUGIYAMA: *Cellulose Commun.* **1**(1), 6–12 (1994) (in Japanese).

Structural variation of native cellulose was reviewed with particular referende to the dimorphysm of crystal structure, crystal orientation, morphology of terminal complexes, and to the phylogeny of life.

The nature of Natadecoco, J. SUGIYAMA: *In "The hundred information of wood", The Association of Japan Forest Engineering,* 60–61 (1995) (in Japanese).

Cellulose is a high performance native fiber produced by the skill of nature, which man cannot achieve so far. The insight of cellulose microfibril is visualized.

Localization of hemicelluloses in the cell wall of some woody plants using immuno-gold electron microscopy, K. BABA, Y. SONE, H. KAKU, A. MISAKI, N. SHIBUYA and T. ITOH: *Holtzforschung,* **48**, 297–300 (1994).

The localization of xyloglucan and glucomannan was determined in the differentiating xylem cells of pine, poplar and bamboo using immuno-gold electron microscopy. Xyloglucan was localized in the primary wall. In bamboo, many gold-particles, which indicated xyloglucan localization, were found in the vessel primary wall, but seldom found in the walls of the other cells. Such a tendency was not seen in pine or poplar. This suggests that either the vessel primary wall of bamboo contains more xyloglucan than the other cells or that the xyloglucan in the vessel wall contains more substituted xylosyl residues than the other cells. Glucomannan was localized clearly in the secondary wall of pine. However, the gold-particles were found only sporadically in the secondary wall of the other species. These findings and the fact that an antibody against tetramannoside was used for the immuno-gold detection of glucomannan suggest that the glucomannan of pine contains a much larger amount of tetrameric fragments of manno-oligosaccharide, than the other species.

Cloning of a lectin cDNA and seasonal changes in levels of the lectin and its mRNA in the inner bark of *Robinia pseudoacacia,* K. YOSHIDA, K. BABA, N. YAMAMATO and K. TASAKI: *Plant. Mol. Biol.*, **25**, 845–853 (1994).

A cDNA clone encoding a lectin was isolated by immunological screening of an expression library prepared from poly(A)$^+$ RNA from the inner bark of *Robinia pseudoacacia*. The cDNA clone (RBL 104) had an open reading frame of 858 bp that encoded a polypeptide with a predicted molecular weight of 31210. This molecular weight corresponded closely to that of a polypeptide immunoprecipotated from products of translation *in vitro* of the poly(A)$^+$ RNA. Thus, RBL 104 appeared to be a full-length cDNA. The *N*-terminal amino acid sequence of the purified lectin matched a portion of the predicted amino acid sequence. It appeared that the lectin was synthesized as a precursor that consisted of a putative signal peptide of 31 amino acids and a mature polypeptide of 255 amino acids. Southern blot analysis of the genomic DNA revealed that the lectin was encoded by a small multigene family. The lectin was mostly localized in the axial and ray parenchymal cells of the inner bark. A small amount of lectin was also found in the axial and parenchymal cells of the xylem. The lectin accumulated in the inner bark in September, remained at high levels during the winter and disappeared in May. The mRNA for the lectin was detected from August to the following March. The appearance and disappearance of the mRNA were observed prior to those of the lectin protein.

Immunological reaction using antiserum for lignin peroxidase of *Bjerkandera adusta,* Y. KIMURA, Y. ASADA and M. KUWAHARA: *Mokuzai Gakkaishi*, **40**, 661–665 (1994).

Polyclonal antiserum for a purified lignin peroxidase (LPO-2) of *Bjerkandera adusta* (Willd: Fr.) Karst. was raised in a white rabbit. The anti-LPO-2 serum formed precipitation lines againts all lignin peroxidases (LPO-1, 2, 3, and 4) of *B. adusta* in Ouchterlony tests. LPO-1 had partial antigenecity of that of LPO-2, and the antigenecities of LPO-1 and LPO-4 were very similar.

In enzyme-linked immunosorbent assay (ELISA) tests, the anti-LPO-2 serum reacted with two lignin peroxidases (LiP-1 and LiP-2) of *Phanerochaete chrysosporium* Burds. and four lignin peroxidases of *B. adusta*. These results indicate that the lignin peroxidases of *B. adusta* have immunogenic peptides and third-structures similar to those of the lignin peroxidases of *P. chrysosporium*.

Degradation mechanism of lignin by steam explosion VI. Steam treatment of milled wood lignin, M. KARINA, M. TANAHASHI and M. KUWAHARA: *Mokuzai Gakkaishi*, **40**, 943–949 (1994).

The degradation mechanism of lignin by steam treatment was studied using milled wood ligmin (MWL) from *Pinus merkusii* Jungh. and De Vriess. The MWL was subjected to a steam treatment (2.05 MPa–212°C for 8 min) with linter cellulose. For further

comparison with the results from pine MWL, wood chips of pine also were subjected to the same treatment. From the steamed pine MWL, coniferyl alcohol was found to be a major product follwed by coniferaldehyde and vanillin, suggesting that the oxidation and reduction of the coniferyl alcohol radical, formed by the homolytic cleavage of the β-aryl ether bond, had occurred. Furthermore, one electron reduction of the radical was a faster process than oxidation to lead to a greater yield of coniferyl alcohol than coniferaldehyde. These compounds scarcely were detected in the degradation products of the acidolyzed MWL. On the other hand, β-oxyconiferyl alcohol (keto and enol forms) and its isomers (2-propanone and 1-propanone) were found as the major degradation products of the pine MWL by acidolysis. The results obtained from the steamed pine MWL was similar to that from the steamed pine wood chips. Then, it was concluded that the main degradation mechanism of lignin by the steam treatment was not an acidolysis but a homolytic cleavage with the formation of the coniferyl alcohol radical.

Degradation mechanism of lignin by steam explosion VII. Steam treatment of syringyl type lignin model compounds, M. KARINA, M. TANAHASHI and M. KUWAHARA: *Mokuzai Gakkaishi,* **40**, 950–957 (1994).

To explain the degradation mechanism of lignin by a steam explosion, syringylglycerol β-sinapylalcohol ether was used in the present study. This model compound was subjected to a steam treatment, 230°C, 2.9 MPa, for 4 min. Steam treatments of sinapyl alcohol-DHP (Dehydrogenation polymer) (S-DHP), sinapyl alcohol-DHP with mannan or syringyl-lignin carbohydrate complex (S-LCC), and white birch (*Betula Piatyphylla,* Sukatchev var. *japonica,* Hara) wood also were conducted.

The major degradation product obtained from steamed syringylglycerol β-sinapylalcohol ether was syringaresinol. Other products found were syringaldehyde, sinapaldehyde, and dihydrosinapyl alcohol. On the other hand, β-oxysinapyl alcohol and its isomers as the major degradation products of acidolysis, were not detected. These results suggest that with the conditions used, the β-ether linkage of syringylglycerol-β-sinapylalcohol ether was cleaved homolytically and produced two sinapyl alcohol radicals. Homocoupling of these radicals mainly occurred to give syringaresinol. It is concluded that main degradation mechanism of lignin by a steam explosion is not an acidolysis but a homolytic cutting reaction followed by the homocoupling of the β-radical to produce syringaresinol.

Production of lipids containing n-6 series poly-unsaturated fatty acids in microorganism II, S. ISHIDA and M. KUWAHARA: *Memoirs of Shiga Women's Junior College,* No. **19**, 1–10 (1994) (in Japanese).

Conidiospores of *Conidioborus obscurus* ATCC 36369 was subjected to UV irradiation to induce the mutants which produce lipids rich in n-6 series poly-unsaturated fatty acids.

Benrate treatment was also examined to induce polyploids. These mutagenesis were found to give no effect on the unsaturated fatty acids of the fungal lipids.

Enzyme chemistry and molecular biology of lignin degradation, M. KUWAHARA: *Chemistry and Biology (Kagaku to Seibutsu),* **32**, 174–180 (1994) (in Japanese).

Production and characterization of ligninolytic enzymes of wood-rotting fungi was reviewed. Genes and expression mechanism of them were also mentioned.

Carbon cycle in natural environment and wood, M. KUWAHARA: In "Wood and Environment", Kaisei-sha, Ohtsu, pp. 9–26 (1994) (in Japanese).

Process of the uptake and emmision of carbon dioxide by woody plants and forest fauna and flora, respectively, was commented.

Ester linkages between lignin and glucuronic acid in lignin-carbohydrate complexes from *Fagus crenata*, T. IMAMURA, T. WATANABE, M. KUWAHARA and T. KOSHIJIMA: *Phytochem.*, **37**(4), 1165–1173 (1994).

Conjugate acid oxidation of benzyl esters with 2, 3-dichloro-5, 6-dicyano-1, 4-benzoquinone (DDQ) and trifluoroacetic acid (TFA) was applied to the binding site analysis of ester linkages between lignin and glucuronoxylan in *Fagus crenata* wood. Based on the conjugate acid DDQ-oxidation of a watersoluble lignin-carbohydrate complex (LCC-WE) from the beech wood, the frequency of the ester bonds between the lignin and glucuronic acid residue of glucuronoxylan was determined to be 1.6 per molecule of LCC-WE.

Neutral glucans from mycelia and fruiting-bodies of *Pleurotus ostreatus*, K. INABA, T. WATANABE, K. DEROMACHI, T. YOSHIDA, T. KOSHIJIMA and T. MITSUNAGA: *Mokuzai Gakkaishi,* **40**, 1141–1146 (1994).

A neutral polysaccharide has been extracted from the mycelia of *Pleuroutus ostreatus* (FR.) Quel with hot water and purified by anion-exchange chromatography and then stepwise precipitation with ethyl alcohol. The polysaccharide has a molecular weight of more than 10^6 and an average chain length of 8. The greatly branched structure resembles that of a typical glycogen which disappeared in to the fruiting-bodies.

Important properties of lignin-carbohydrate complexes (LCCs) in environmentally safe paper making, T. WATANABE: *Trends in Glycosci. Glycotechnol.*, **7**(33), 57–68 (1995).

Lignin-carbohydrate complexes (LCCs) are glycoconjugates in which hydrophobic lignin is chemically bound to hydrophilic polysaccharides in wood cell walls. Alkali-stable linkages in the amphipathic substances are one of the major origins of chromophoric substances remaining in kraft pulp. Because decolorization of the chromophore with chlorinated chemicals results in the production of toxic substances, microbial conversion of

the chromogens has gathered much interest in this decade. However, the nature of lignin-carbohydrate complexes in the pulp has not been systematized and reactivities of LCC during the biobleaching have not been analyzed of a molecular level. Chemical analysis and microbial cleavage of the alkali-stable lignin-carbohydrate bonds are indispensable for environmentally safe paper making. In this paper, the origin and reactivities of LCCs in kraft pulp are reviewed.

Production and biological activities of cellooligosaccharides, T. WATANABE, M. SATAOUCHI, T. TSUMIYA, T. KOSHIJIMA and M. KUWAHARA: *Preprints of Kyoto Conference on Cellulosics-A Post Symp. of ISF,* 89 (1995).

Sugar torerance and cecal fermentation tests were carried out using cellobiose produced by continuous hydrolysis of cellulose with a membrane bioreactor specially designed for the hydrolysis of insoluble polymer. As a result, it has been found that cellobiose produced predominantly butyric acid by the action of the intesitinal microflora, suggesting that cellobiose is effective for a regenaration of intestinal mucosa cells.

Digestibility, sugar torerance effects and α-glucosylation of cellobiose produced by membrane bioreactor, T. WATANABE, M. SATAOUCHI, T. TSUMIYA, M. NAKAJIMA, T. KOSHIJIMA and M. KUWAHARA, S. WAKABAYASHI and K. OHKUMA: *Proc. of '94 Cellulose R & D,* The Cellulose Society Japan, Tokyo, 81–86 (1995).

Cellobiose was continuously produced from cellulose with a membrane bioreactor designed for an enzymatic hydrolysis of insoluble polysaccharides. The produced cellobiose was stable to human saliva amylase, artificial gastric juice and porcine pancreatic amylase, however, it was partially hydrolyzed by intestinal mucosa cell homogenates of rat to produce a small amount of glucose. When cellobiose and several digestible sugars were administrated orally in rats, blood glucose and insulin levels after loading of cellobiose were found to be lower than those of the digestible sugars. Linear homooligosaccharides having α-1, 4- and β-1, 4-glucosidic llinkages were synthesized from cellobiose and starch by transglycosylation with cyclodextringlucanotransferase from *Bacillus macerans.*

Comparative analysis of functional and structural features in the primase-dependent priming signal, G sites, from phages and plasmids, K. TANAKA, T. ROGI, H. HIASA, D. MIAO, Y. HONDA, N. NOMURA, H. SAKAI and T. KOMANO: *J. Bacteriol.,* **176,** 3606–3613 (1994).

The primase-dependent priming signals, G sites, are directly recognized by the *Escherichia coli* primase (*dnaG* gene product) and conduct the synthesis of primer RNAs. In nucleotide sequence and secondary structure, there is no striking resemblance between the phage-and plasmid-derived G sites, except for the limited sequence homology near the start position of primer RNA synthesis. In this study, the structure and function relationships of

G sites derived from R100 plasmid and G4 phage were analysed. It was shown that these G sites have functionally equvalent domeins which are able to substitute for each other.

Genes encoding ligninolytic enzymes of wood-rot-fungi, Y. HONDA and M. KUWAHARA: *Nippon Nogeikagaku Kaishi,* **69**, 365–368 (1995) (in Japanese).

Recent advances in the analysis of genes specifing lignin-degradating enzymes, lignin peroxidase (LiP) and manganese-dependent peroxidase (MnP), from white-rot fungi were reviewed. Future prospects of this field were also presented.

Single crystals of regio-selectively substituted cellulose hetero-esters, T. IWATA, K. OKAMURA, J. AZUMA, H. CHANZY and F. TANAKA: *Cellulose,* **1**, 67–76 (1994).

Lamella single crystals of some regio-selectively substituted cellulose hetero-esters: cellulose propionate diacetate (CPDA, 2, 3-di-*O*-acetyl-6-*O*-propionyl cellulose), cellulose acetate dipropionate (CADP, 6-*O*-acetyl-2, 3-di-*O*-propionyl cellulose), cellulose butyrate (diacetate (CBDA, 2, 3-di-*O*-acetyl-6-*O*-butyryl cellulose) and cellulose acetate dibutyrate (CADB, 6-*O*-acetyl-2, 3-di-*O*-butyryl cellulose), have been prepared at high temperature in a mixture of dibenzyl ether and *n*-tetradecane. The CPDA crystals were lozenge -shaped whereas those of CADP, CBDA and CADB had a ribbon morphology. CPDA crystals gave well-resolved electron diffractograms from which the reciprocal lattice parameters $a^*=0.807\ \mathrm{nm}^{-1}$, $b^*=0.400\ \mathrm{nm}^{-1}$ and $\gamma^*=90°$ could be determined. Systematic absences occurred at every odd reflection along the two orthogonal axes a^* and b^*. Thus, the CPDA diffraction pattern is consistent with a p_{gg} symmetry. For CADP, the electron diffraction pattern is consistent with p_{mg} two-dimensional space group with b the unique axis along the ribbon direction. The diagram yields the reciprocal lattice parameters $a^*=0.902\ \mathrm{nm}^{-1}$, $b^*=0.651\ \mathrm{nm}^{-1}$ and $\gamma^*=90°$. The CBDA electron diffractogram yields the following cell parameters and two-dimensional space group: $a^*=0.482\ \mathrm{nm}^{-1}$, $b^*=0.659\ \mathrm{nm}^{-1}$ and $\gamma^*=90°$, and a p_{gg} symmetry; and that of CADB: $a^*=0.834\ \mathrm{nm}^{-1}$, $b^*=0.645\ \mathrm{nm}^{-1}$ and $\gamma^*=90°$, and a p_{mg} symetry.

Characterization of cellulose using molecular simulation technique, F. TANAKA and A. SARKO: *Proceedings of '94 Cellulose R & D,* 11–14 (1994).

The relationship between structure and properties of Cellulose molecule was examined through molecular simulation technique. Energy surface of cellulose was calculated using MM2 program with MM2CARB parameter set. Dynamic structural changes of cellulose was obtained in MM2 force field with MM2CARB parameter set using molecular dynamics simulation technique. From both of static and dynamic simulations, several characteristics of cellulose molecules were obtained. (1) A conformational feature of cellobiose unit was classified into two groups. (2) Cellobiose unit can change its conformation even in a crystalline state. (3) A structural aspects of cellulose can be explained only by the

interactions between adjacent residues. (4) Steric effects and hyperconjugation around anomeric carbons are major factors which put conformational changes of cellulose molecule under constraint. Hydrogen bonding seems to be not so important. (5) Cellulose chains are not so rigid.

Crystal Structure of Regio-Selectively substituted cellulose hetero-esters, T. IWATA, K. OKAMURA, J. AZUMA, F. TANAKA, H. CHANZY and K. MAZEAU : *Proceedings of '94 Cellulose R & D,* 15–18 (1994).

The molecular and crystal structure of two regio-selectively substituted cellulose hetero-esters, cellulose propionate diacetate (CPDA) and cellulose acetate dipropionate (CADP), have been investigated by X-ray and electron diffraction methods. The unit cell of CPDA is an orthorhombic with parameters : a=1,239 nm, b=2.498 nm and c (fiber axis)=1.044 nm, and space group is $P2_12_12_1$. CPDA single crystals occur as platelets having a lozenge-like appearance. On the other hand, CADP crystallizes as a monoclinic unit cell with parameters : a=1.088 nm, b=1.593 nm, c (fiber axis)=1.509 nm and β=94.1°, and space group is $P2_1$ as b the unique axis. CADP single crystal occur as ribbon-like radiating from a common nucleation center.

Permanent fixation of compressed wood. Hygro-thermal treatment in a closed system, M. INOUE and M. NORIMOTO : "Properties and utilization of fast-growing trees", China Forestxy Publishing House, Beijing, 56–64 (1994).

We have developed a new process to permanently fix the compressive deformation of wood. In this process, a hygro-thermal treatment using moisture in wood in a closed system was applied. Sugi (*Criptomeria japonica* D. Don) specimens were compressed in a redial direction and heated in a hot press equipped with an airtight silicone sheet seal. Following the treatment. the specimens were rapidly quenched in the press.

The recovery of the compression set after boiling in water decreased with increasing of heating time and temperature. The fixation of the set was achieved when the specimens with a 17% moisture content were compressed for 8 minutes at 180°C. However, the effect of the treatment on the fixation could not be observed for the dry specimen, so we conclude that the moisture in wood acted on the fixation of the deformation in wood.

Permanent fixation of compressive deformation of wood by crosslinking, M. INOUE, K. MINATO and M. NORIMOTO : *Mokuzai Gakkaishi,* **40**, 931–936 (1994).

One of the methods to permanently fix the compressive deformation of wood is to form crosslinking between the wood components in a deformed state. To confirm this, vapor and liquid phase formalizations were investigated.

The compressed wood was treated with tetraoxane (cyclic tetramer of formaldehyde) and SO_2 (catalyst) in a dry condition at 120°C for 2 hours. The deformation was fixed perfectly

even after boiling in water for 8 hours. The same results were obtained by the reaction at 135°C for 20 minutes with SO_2 and formaldehyde vapor generated from paraformaldehyde. However, the deformation was recovered by soaking in a H_2SO_4 water solution. From these facts it may be condluded that permanent fixation through formalization is ascribed to the formation of crosslinking between wood components. By vapor phase formalization. mechanical Properties remained almost unchanged. On the other hand, the complete fixation was not realized by liquid phase formalization, although the recovery of set decreased with increasing treating time.

Acoustic properties of cane (*Arundo donax* L.) used for reeds of woodwind instruments I, The relationships between vibrational properties and moisture contents of cane, E. OBATAYA and M. NORIMOTO: *Mokuzai Gakkashi,* **41**(3), 289–292 (1995).

The relationships between vibrational properties and moisture contents of cane (*Arundo donax* L.) used for the reeds of woodwind instruments were investigated and compared with those of spruce (*Picea sitchensis* Carr.). After the water extraction, the dynamic Young's modulus of cane decreased at below 15% moisture content (m.c.) and remained almost unchanged above 15% m.c. At about 7% m.c., the loss tangent of cane had its maximum value, and that of spruce had its minimum value,which was a remarkable difference. After the extraction, however, the moisture content dependence of the loss tangent of cane resembled that of wood. From these results, it was considered that the extractives existing in the cell walls of cane acted to reinforce the cell-wall structure at low moisture content levels. However, they absorbed much moisture and dissolved at high moisture content levels, so that this effect was lost.

Acoustic properties of cane (*Arundo donax* L.) used for reeds of woodwind instruments II, Analysis of vibrational properties by a viscoelastic model, E. OBATAYA and M. NORIMOTO: *Mokuzai Gakkashi,* **41**(5), 449-453 (1995).

The effects of moisture and extractives on the vibrational properties of cane (*Arundo donax* L.) were analyzed by using a viscoelastic model. Extractives incease the modulus of elasicity (E_m) and the coefficient of viscosity (η_m) of the matrix substance in the cell walls of cane in the range of 0% to 18% moisture content (m.c.). This action is remarkable at low levels of m.c. Although both E_m and η_m of untreated cane decrease more than that of extracted cane with increasing m.c. above 3%. It is considered that these decreases are due to the dissolution of the extractives by moisture absorption, and the more remarkable decrease of η_m than of E_m is the reason for the loss tangent ($\tan\delta$) maximum at about 7% m.c. for the untreated cane. On the other hand, in the extracted cane, E_m and η_m increase up to 2% m.c. and then decrease. It is considered that the decrease of than $\tan\delta$ from 0% m.c. to about 7% m.c. is due to the arrangement of the molecular chains of the matrix

substance, and the increase of tan δ above 7% m.c. is due mainly to the increase of the volume fraction of the matrix substance by swelling.

Physical and mechanical properties of pernambuco (*Guilandina echinata* Spreng), M. SUGIYAMA, M. MATSUNAGA, K. MINATO and M. NORIMOTO : *Mokuzai Gakkaishi,* **40**(9), 905–910 (1994).

Physical and mechanical properties of the heartwood of pernambuco (*Guilandina echinata* Spreng), a kind of Brazilian hardwood, were investigated from the viewpoint of its function as bows for violins. The oven-dried specific gravity of pernambuco ranged widely from 0.7 to 1.1, and its mean value was 0.92. The Young's modulus of pernambuco varied more than did those of other wood species of the same specific gravity. However, the values overlapped with those of other wood species. Moreover, from the fact that the bending property is adjustable by the diameter or cross sectional figure of the bow, it is supposed that the Young's modulus of pernambuco is not always indispensable for violin's bow. On the other hand, the loss tangent of pernambuco was surprisingly less than that of any other wood species when compared at the same specific gravity or specific Young's modulus. This characteristic coincides with the function of a bow, and thus may be necessary for the bow. The small value of loss tangent was related closely with the water extractable components contained.

Transverse compression of wood and its application to wood processing, M. NORIMOTO : *Wood Research and Technical Notes,* No. **30**, 1–15 (1994) (in Japanese).

Recent investigation on the large compressive deformation of wood in the transverse direction and the methods of its permanent fixation were reviewed.

Heat and steam treatment of wood, M. NORIMOTO : *Wood Industry,* **49**(12), 588–592 (1994) (in Japanese).

The effect of steam or heat on the fixation of the large transverse compressive deformation of wood was reviewed.

Rheological properties of wood under high temperature steam condition, T. MOROOKA, M. INOUE, S. KAWAI and M. NORIMOTO : *Proc. of the International Symposium on the Utilization of Fast-Growing Trees,* China, pp. 65–71 (1994).

By using newly developed testing machine, we measured rheological properties of wood in compression under high temperature (up to 200°C) steam condition. Both the Young's modulus and yield stress decreased with increasing temperature or steaming time although the stress-strain diagram measured over a wide strain range are similar in shape with each other. All the relaxation modulus curves measured below 100°C were similar in shape irrespective of the temperature examined, while those above 100°C were different with each other, indicating different relaxation mechanism below and above 100°C. In relation to the

permanent fixation of wood in compression state, we also measured stress relaxation of wood in a large compressive deformation state. With increasing steaming time, the value of stress decreased until it leveled off when steamed below 160°C while it reduced to nil in 15 min. when steamed at 180°C.

The large compressive deformation of wood in the transverse direction. The effect of steam treatment on stress-strain diagram, Y. LIU, M. NORIMOTO and T. MOROOKA : *Proc. of the International Symposium on the Utilization of Fast-Growing* Trees, China, pp. 665–670 (1994).

In order to clarify the effect of steam tratment (140°C–200°C and 2–8 min) of wood on the mechanical properties, we performed the large compressive deformation test in the radial direction for the treated wood under three conditions ; namely, air-dried conditions at 20°C, the wet condition at 20°C and the wet condition at 100°C. Comparing the results for the samples with the same treating time, both the Young's modulus (E) and yield stress (σ_y) decreased with an increase in treating temperature. In addition, their drop rate with temperature was remarkable for the samples in the wet condition at 100°C. Similar decrease in σ_y and E were observed when the treating time was increased instead of the increase in treating temperature. In addition to the single compression test mentioned above, we also conducted multicycle tests for the treated wood by increasing strain levels. At each cycle, we observed residual strain (ε_0), σ_y and E for the above three conditions. As for the results obtained in the wet condition, σ_y and E decreased while ε_r increased by increasing strain levels. When comparisons are made at the same strain level, 200°C treatments caused highest ε_0 value and lowest σ_y and E values of all the treatments examined. The results for air-dried specimens were quite different to the above.

Wood drying and improvement by smoke-dry heat treatment with EDS (Ecology dry system), T. NOMURA and S. ISHII : *Proceedings of the 4th IUFRO conference on wood drying,* 382–389 (1994).

Ecology dry system (EDS) involes smoke-dry heat treatment of wood while improving wood quality. This system is capable of drying a large volume (maximum of 200 m^3) of wood efficiently. It composed of a sealed wood drying room and a gas combustion generator provided with an air-inlet conduit introducing air into the combustion chamber located at the lower section of the system. In this system, the gas combustion recovery conduit may be directry connected to the gas combustion generator with the possiblity of connecting with the air-inlet conduit. This system was constructed in such a way that the waste wood and the fuel are burned in the gas combustion generator to produce combusted hot gas accompanied with the emission of smoke. Then, the hot gas is introduced into the wood drying room through the gas combustion supply passage.

In the above operation, the wood drying room is filled with combusted hot gas with

water vapor and smoke. In this condition, the temperature in the wood drying room gradually increased until it reaches a temperature of 150°C–160°C within two daus. After aggaining the maximum temperature, it then decreaes gradually as the fuel was consumed and reached the same as the outside temperature after 7 to 10 days.

In this process, the core temperature in the wood gradually increased by about 2°C/h without exceeding 100°C but instead maintaining a temperature between 70 to 100°C during a period of about 60 h. At this point, lignin is softened while relaxation of internal stresses in wood takes place. The final moisture content of the green log after the process was about 40–55%.

Duration under load of glueline exposed to fire, S. ISHIHARA, H. SASAKI, Q. WANG and S. KAWAI: *Proc. from the Adhesives and Bonded Wood Symposium,* 177–183 (1994).

Unprotected glued laminated lumber under a constant load was exposed to fire from three sides following the Japanese Industrial Standard (JIS A1304). Straight rectangular lumber composed of Douglas fir (*Pseudotsuga menziesii* Franco) lamina of different thicknesses was glued with room temperature-setting resins. The glues applied were resorcinol-formaldehyde resin, epoxy resin, and aqueous solution of vinyl-isocyanate polymer. The fire endurance of these glues was found to be, in decending order : resorcinol-formaldehyde, polyvinyl-isocyanate, epoxy resin. Little difference between the fire endurance of resorcinol-formaldehyde and polyvinyl-isocyanate was found. Duration of the epoxy glueline exposed to fire was about half that of the resorcinol-formaldehyde glueline. Fire endurance of all gluelines increased as their distance from the surface exposed to fire increased.

Super conductor from wood, S. ISHIHARA: *100 Wonders of Wood,* 204–205 (1995) (in Japanese).

Fire-resistant carbon-based board materials. V. Fire endurance of fire doors and double-walled construction boards and particleboards overlaid with graphite-phenolic spheres, I. IDE, S. ISHIHARA, S. KAWAI, Y. YOSHIDA, M. NAKAJI, H. HIGUCHI and A. TAKAMATU: *Mokuzai Gakkaishi,* **40**, 631–639 (1994) (in Japanese with English summary).

For actual applications, the fire-resistant properties of full-scale carbon-overlaid composites were determined.

Graphite phenol-formaldehyde spheres (GPS) were produced by phenol-formaldehyde condensate on graphite powder. The resulting thermosetting resin in powder form was used as an overlay material for both surfaces of particleboard cores in the production of full-scale fire-resistant boards. The effects of board thickness and the weight ratio (GPS surface layer to the board) on the fire endurance of the GPS-overlaid particleboards were investigated. Also, the fire endurance of full-scale double wall boards and doors with GPS-overlays were tested following the Japanese Industrial Standard (JIS A1304) for fire tests.

The fire endurance was improved with increases in board thicknesses. The fire performance of 40 mm thick GPS-overlaid particleboard of different weight ratios were observed to be more than 80 mins. For boards exposed to fire exhibited no burn-through even after the unexposed surfaces exceeded the critical temperature of 260°C. These boards are recommended as GPS-overlaid particleboards for fire endurance of one hour.

The endurance of a double-wall GPS-overlaid particleboard was 93 mins.

The fire endurances for three samples of full-scale size, these are, two-layer board, 70 mm, 70 mm and 60 mm, were 90, 96 and 70 mins., respectively. The fire-resistant doors exposed to fire did not show any burn-through even after the exposed surfaces exceeded the critical temperature of 260°C. The three samples tested are recommended for use in conventional type doors in wooden structures.

Detection of acoustic emission (AE) generated by the feeding activity of *Semanotus japonicus* Lacordaire, Y. FUJII, Y. IMAMURA and E. SHIBATA : *Japan J. Environ. Entomol. Zool.*, **6**, 112–118 (1994) (in Japanese with English summary).

Acoustic emission (AE) was detected from young logs of Japanese ceder (Sugi in Japanese) inhabited by a larve of the sugi bark borer, *Semanotus japonicus* Lacordaire. This AE generation is attributable to the feeding or some other activities of the larva, boring galleries in the sapwood of the log. From the attenuation of artificial AE waves in the log and the relationships between the detected AEs and the sensor position from the larva, the feasible monitoring area of a sensor is discussed.

Strength losses in wood composites and biological failure in gluelines, Y. IMAMURA : *Proc. Adhesives & Bonded Wood Symposium,* C-Y Hse, B. Tomita and S.J. Branham, eds., Forest Products Society, USA, 184–193 (1994).

Since decay fungi considerably reduce the strength of wood composite materials such as particleboards or flakeboards at slight weight losses, diagnosing fungal resistance on the basis of weight loss is not reliable. A testing method combining bending deformation and decay hazard was applied to wood-based boards to evaluate their mechanical performance under fungal attack. Deflection-time curves showed significant patterns that enable evaluation of strength reduction caused by the action of fungi. A rapid reduction of mechanical strength during early stages of decay was assumed to be due to active fungal invasion onto the surfaces of wood particles and consequent glue failures. Variations in decay resistance depend on the manufacturing conditions and types of treatments as well as the species of attacking fungi. The phenol-formaldehyde particleboard lasted longer until fracture than the urea-melamine-formaldehyde board or isocyanate board. Scanning electron-micrograph of the fractured surfaces present visible evidence on glue-line failures due to fungal attack. Incorporation of fungicides in the glue is considered to be more effective against fungal growth on the particle surface and prevent glue-line failure.

Biological resistance of wood-mineral composites using the water glass-boron compound system, T. FURUNO and Y. IMAMURA : *Proc. Second Pacific Rim Bio-Based Composites Symposium, Vancouver,* 92–101 (1994).

Biological resistances of wood-mineral composites made using the water glass-boron compound system were evaluated in relation to the role and applicability of boron compounds as reactants to form the insoluble inorganic substances.

Sapwood specimens of Japanese cedar (*Cryptomeria japonica* D. Don) were diffused-penetrated with water glass (sodium silicate) followed by soaking in the saturated solutions of boron compounds (boric acid, borax, boron trioxide, ammonium borate, and potassium borate) and other reactants (double treatment). Composites were also made with boron compounds alone (single treatment), and termite and decay resistances of the two types of composites were compared.

After the leaching procedure, the composites using the water glass-boron compound system showed generally excellent termite resistances with the negligible weight losses of specimens and high mortalities of workers and soldiers. On the contrary, the single treatments and the double treatments using other reactants of non-boron compounds showed slight or little resistances against termite attacks, accounting for the high leachability of the inorganic substances and/or low effectiveness of the chemicals.

Also, the water glass-boron compound system was found to enhance greatly the decay resistances if water-soluble inorganic substances were fully removed out from the specimens. The formation of insoluble inorganic substances in the water glass-boron compound system proved to contribute much to the enhancement of biological resistances.

The efficacy of preservatives incorporated in the glue of particleboards and plywoods, B. SUBIYANTO, Y. SUDIYANI, S. YUSUF, Y. IMAMURA, S. FUSHIKI, T. SAITO and Y. KATUZAWA : "Properties and Utulization of Fast-Growing Trees", C. Chison, H. Sasaki and H. Yukan, eds., p. 234–243, China Forstry Publishing House, Beijing (1994).

Preservative treated particleboards and plywoods were prepared using tropical fast-growing species albizzia *(Paraserienthes falcataria)* and lauan (*Shorea* spp.), respectively as raw materials. Particleboards and plywoods were treated by adding insecticides and fungicides to the adhesive-glue, and the physical and biological properties of these boards were evaluated. No significant reduction in bending or internal-bond strength due to incorporation of the chemicals was detected. Treated particleboards and plywoods effectively resisted attack by *Coptotermes formosanus* at an active ingredient (a.i.) retention of less than 350 g/m^3 for chlorpyrifos. Dichlorophenthion and propetanphos showed the same efficacy for albizzia particleboards in laboratory tests. Treated lauan plywoods were able to inhibit effectively the decay by both *Tyromyces palustris* amd *Coriolus versicolor* at an a.i. retention of more than 0.5 kg/m^3 of IF-1000. Although decay of albizzia particleboards was

unaffected by incorporating the preservative at the retention levels in this study, boards which contained IF-1000 as a fungicide at an a.i. retention of more than 1.0 kg/m^3 showed the possibility of decay resistance.

Control of wood biodeterioration for high-performance of wooden houses, Y. IMAMURA: *Mokuzai Kogyo (Wood Industry),* **49**, 531–535 (1994) (in Japanese).

The present situations and prospects for control of wood biodeterioration in houses were described from a view point of enhancement of their performance.

Properties-enhanced albizzia particleboards by incorporating fungicide and insecticide in the glue, B. SUBIYANTO, S. YUSUF, Y. IMAMURA, S. FUSHIKI, T. SAITO and Y. KATUZAWA: *The Int. Res. Group on Wood Preserv.,* Document No. IRG/WP/94–30060, pp. 11 (1994).

Preservative-treated particleboards were prepared using tropical fast-growing albizzia and adding fungicides and insecticides to the adhesive-glue. The physical and biological properties of these boards were evaluated. No significant reduction in bending or internal-bond strength due to incorporation of the chemicals was detected. Treated particleboards effectively resisted attack by *Coptotermes formosanus* at an active ingredient (a.i.) retention of less than 350 g/m^3 for chlorpyrifos, dichlorophenthion and propetanphos in laboratory tests. Although decay was unaffected by incorporating the mixed preservative at the retention levels in this study, boards which contained IF-1000 as a fungicide at an a.i. retention of more than 1.0 kg/m^3 showed the possibility of decay resistance.

Analysis of feeding activities of termites by AE monitoring of infested wood, Y. IMAMURA and Y. FUJII: *Mokuzai Hozon (Wood Preservation, Japan),* **21**, 61–69 (1995) (in Japanese with English summary).

The mode of feeding behaviors of termites were investigated by monitoring the acoustic emissions (AEs) generated from the wood under their attacks, as it had been revealed that the generation of AE events was evidently relevant to the activities of feeding.

The AE events began to generate from the wood specimens coexisted with termites of *Coptotermes formosanus* at about a few hours to more than ten hours after setting of the tests, and increased rapidly. After then they decreased and kept a constant rate for a while, and again they increased at about a few days after starting of the tests. The AE event rate repeated the cycles of increase and decrease periodecally. Even with the same number of inhabiting workers, AEs were generated at higher rate from the specimen with soldiers than without soldiers. It was suggested that the feeding activities were accelerated by soldiers who were fed on workers. AE events decreased as the ambient temperature fell from the degree of 27°C and stopped at 12°C. AEs were generated again after rising of the ambient temperature, and continued to increase with ascending temperature until 36°C. After that,

AE events decreased and stopped at more than 40°C, and they were no more detected even the ambient temperature were fell down. The generation of AEs dropped or stopped by the exposure to lighting, suggesting that the activities of feeding of the termites were influenced by irradiation of light. The AE events began to generate once again even from the wood specimens under the exposure of lighting after a while.

Creep behavior of wood and composite wood under fire, T. HATA, SUBYAKTO, K. NISHIMIYA, H. GETTO and S. ISHIHARA : "Properties and Utilization of Fast-Growing Trees", C. Chison, H. Sasaki and Hua Yukun eds., p. 176–184, China Forestry Publishing House, Beijing (1994).

Solid wood of Albizia (*Albizia falcata* Becker), Kapur (*Dryobalanops* sp.) and Sugi (*Cryptomeria japonica* D. Don) ; and 2 and 3 layers composite wood of Albizia and Kapur were treated with Trimethylolmelamine and Phosphoric acid condensate; and their creep behavior under fire was evaluated. Comparatively, treated samples had significant fire endurance than the untreated ones. Solid wood of Kapur exhibited the highest time to creep rupture followed by Sugi and Albizia. It was observed that the number of layers favorably improve the fire endurance of composite wood.

Situation of wood based panels in north america, T. HATA : *APAST,* **12**, 21–23 (1994) (in Japanese).

The real situation of OSB production which was investigated on December 2nd to 12th, 1993. The direction in near future of wood panel industuy was also explained.

Simple production technology of panels, T. HATA : In "100 Wonders of wood" The Association of Japan Forest Engineering, 178–179 (1995) (in Japanese).

The production technology of wood based panels and steam-injection pressing technology are reviewd.

Applied lecture on antifungal and antibacterial chemical agents—Present situation and future prospect of end-use examples by use field (3). Antibacterial and antifungal chemical agents for wooden products, M. TAKAHASHI : *J. Antibact. Antifung. Agents,* **23**(2), 115–119 (1995) (in Japanese).

Current commercially-used wood preservatives in Japan were described, including treatment methods, formulations, designated retentions and penetrations, etc. The proper use of preservative-treated wood products should be considered in several aspects such as the extent of biological attack during their use, their desired service life and the risk assessment derived from their use.

Termiticidal efficacy of synthetic pyrethroids 2. Effect of accelerated ageing of their termiticidal performance, K. TSUNODA : *Wood Protection,* **2**(2), 67–73 (1993).

This paper describes the effect of heat exposure and soil burial on the termiticidal efficacy of two synthetic pyrethroids (cyhalothrin and lamda-cyhalothrin) applied by brush treatment to pine sapwood blocks (10×10×20 mm) at a rate of 110±10 g/m^2. Treated wood blocks were exposed to heat ageing at 40±2°C or burial in the unsterile soil at 26 ± 2°C for periods of time prior to termite bioassay and GLC analysis of residual pyrethroids. Heat exposure for 1–12 months did not result in decreased termiticidal effectiveness. The lowest test concentrations [0.1% (w/v) cyhalothrin and 0.05% (w/v) lamda-cyhalothrin], met termiticidal performance requirement (<3% weight loss) Japan Wood Preserving Association Standard 14 (1981). Chemical analysis, on the other hand, demonstrated that the recovery rates of the test chemicals decreased with time and that the residual amount was occasionally reduced by nearly half in the longest heat ageing. Longer periods of soil burial accounted for more serious damage to the wood blocks because of the greater loss of active ingredients caused by microbial activities in the soil. Cyhalothrin succeeded in protecting wood blocks from termite attack at treating concentrations of 0.2% (w/v) and above even after 12 weeks soil burial. Lamda-cyhalothrin, when it was reinforced by 0.5% (w/v) IPBC, proved effective at 0.2% (w/v), whereas treated blocks sustained over 3% weight loss without IPBC after 12 weeks soil burial. The results clearly indicated that, after accelerated ageing, termiticidal performance of cyhalothrin and lamda-cyhalothrin was comparable with that of the commercialized synthetic pyrethroids.

Evaluation of a new anti-sapstain formulation, K. TSUNODA, H. KUMAGAI and M. SAKURAI: *The Int. Res. Group on Wood Preserv.*, Document No. IRG/WP 94–30035, pp. 5 (1994).

A new anti-sapstain mixture, which consists of 2% IPBC (3-iodo-2-propynylbutyl carbamate) and 1.5% DCOI (4, 5-dichloro-2-*n*-octylisothiazolin-3-one), was evaluated by three methods in the laboratory. A standardized test (JWPA standard 2) demonstrated that the new anti-sapstain formulation was highly effective in controlling growth of monocultures of five test fungi on wood substrate. When exposed to mixed spore suspension, the formulation performed better than TCP-based commercial product.

A larger scale laboratory tests and supplemental trials at sawmills also supported a satisfactory performance of the formulation to protect freshly sawn timber from moulds and sapstain fungi.

Biological resistance of wood-inorganic material composites (III). Role of boric acid added to the treating solutions for improving biological resistance, K. TSUNODA, S. KIRITA and M. TAKAHASHI: *Proc. 2nd Pacific Rim Bio-Based Composites Symp.* (compiled by P.R. Steiner), Nov. 6–9, 1994, Vancouver, Canada, p. 102–108 (1994).

Sound sapwood blocks of *Cryptomeria japonica* D. Don [20(*T*)×20(*R*)×10(*L*) mm] were consecutively dipped in the two kinds of aqueous solutions to form water-insoluble deposits

such as $BaHPO_4$ within the wood. Addition of boric acid to the second anion solution of $(NH_4)_2HPO_4$ definitely resulted in the improvement of decay resistance even after exposing to non-running water for over 100 hours when boric acid in the wood blocks was still measurable with an ion chromatograph, although the quantity of boric acid itslf did not seem to be sufficient for producing a satisfactory protection against termites. Some boric acid and borate ion, therfore, should be held to provide the final wood-inorganic material composites with a good biological resistance.

X-ray diffractometry was applied to examine crystal structure of water-insoluble deposits formed in the wood after double diffusion treatment. When boric acid was added to either of the treating solutions, $BaHPO_4$ was distinguished as expected. In contrast, the peak of $BaHPO_4$ was not prominent after eaching when both cation ($BaCl_2 \cdot 2H_2O$) and anion solutions contained boric acid. The finding suggested that the involvement of boric acid brought about the change of reaction mode among chemicals under the presence of lignocellulosic materials.

Alternative protection of Japanese houses from subtarranean termite invasion, T. YOSHIMURA and K. TSUNODA: "Les Insectes Sociaux", Proc. 12th Cong. IUSSI, Paris, 1994, Publ. Univ. Paris Nord, p. 259 (1994).

Typical Japanese houses are timber-frame construtions on the concrete base (wall footing, 30–50 cm above the ground level) so that crawl space is present between floor and ground. Various alternative treating methods, which have been developed in Japan to prevent termite invasion through crawl space, were described.

Termites and their contribution to natural cycling system of wood, T. YOSHIMURA: "Wood and Environment", M. KUWAHARA ed., Kaiseisya Publ., p. 110–124 (1994) (in Japanese).

The interactions between insects and plants were outlined with special reference to the role of termites in natural cycling system of wood.

Changes of wood-attacking activity of the lower termite, *Coptotermes formosanus* Shiraki in defaunation-refaunation process of the intestinal protozoa, T. YOSHIMURA, J. AZUMA, K. TSUNODA and M. TAKAHASHI: *Material und Organismen*, **28**(2), 153–164 (1993/1994).

Changes of wood–attacking activity of the lower termite, *Coptotermes formosanus* Shiraki, in a defaunation-refaunation process of the intestinal protozoa were investigated in order to discuss the contribution of the protozoa in terms of wood decomposition. The largest protozoa, *Pseudotrichonympha grassii* Koidzumi, was selectively eliminated within five weeks by feeding on low-molecular weight cellulose ($\overline{DP}=17$) without any detrimental effect on the termites' health conditions. Elimination of *P. grassii* caused a 30% reduction of wood-

attacking activity, but the activity rapidly recovered by the one week's co-feeding with freshly collected workers. Completely defaunated workers hardly consumed wood blocks even after one week's successful refaunation. From the results obtatned, it is concluded that wood consumption by workers of *C. formosanus* largely depends on the protozoan fauna in their hindguts.

Cellulose metablism of the symbitic protozoa in termite, *Coptotermes formosanus* Shiraki (Isoptera: Rhinotermitidae) IV. Seasonal changes of the protozoan fauna and its relation to wood-attaking activity, T. YOSHIMURA, K. TSUNODA and M. TAKAHASHI: *Mokuzai Gakkaishi,* **40**(8), 853–859 (1994).

Six colonies (three each from laloratory and field) of *Coptotermes formosanus* Shiraki were used to investigate the seasonal changes of the symbiotic protozoa in the hindguts of workers in conjunction with their wood-attacking activities. The total protozoan numbers amounted to 5,130–12,880/worker for laboratory colonies, and 3,750–11,140/worker for field colonies. The order of abundance of the three symbiotic protozoa and the proportional distribution of each species in the hindguts were common among the colonies throughout the year. *Pseudotrichonympha grassii* Koidzumi (largest species) was found preferentially in the anterior parts of the hindguts, and was the fewest in numbers (480–2,160/worker). *Holomastigotoides hartmanni* Koidzumi (intermediate size) was intermediate in numbers (740–4,180/worker), and its distribution was relatively uniform throughout the hindguts. *Spirotrichonympha leidyi* Koidzumi (smallest species) was the most abundant (2,240–10,880/worker), and was found mainly in the posterior parts of the hindguts. A characteristic seasonal dependence was observed only in the numbers of *H. hartmanni* in field colonies, which showed gradual changes from the lowest levels in winter to the highest levels in the late summer and autumn. Wood-attacking activities in field colonies were least in winter, and these gradually went up to the highest levels in autumn. This tendency was quite opposite to that of laboratory colonies. The abundance of *H. hartmanni* was positively related to wood-attacking activities. This suggests that *H. hartmanni* plays an important role in the digestion of wood in the hindguts of *C. formosanus.*

Cellulose metabolism of the symbiotic protozoa in termite, *Coptotermes formosanus* Shiraki (Isoptera: Rhinotermitidae) V. Effect of crystallinity of cellulose, T. YOSHIMURA, J. AZUMA, K. TSUNODA and M. TAKAHASHI: *Mokuzai Gakkaishi,* **41**(2), 206–210 (1995).

When workers of *Coptotermes formosanus* Shiraki were forced to feed on cellulose having various crystallinity index (CrI), the survival rates and weigths of workers, the numbers of differentiated soldiers, and the changes of protozoan fauna were studied. Although all cellulose substrates (CrI: 13.1–88.5%) and wood meal of akamatsu (*Pinus densiflora* Sieb. et Zucc.) were utilized without difficulty by the workers, cellulose having CrI of approximately

40–70% was demonstrated to be well-nourishing. From the faunal changes, it was suggested that the crystallinity was not an essential factor affecting the utilization of cellulose by each protozoan species.

Effect of starvation on the protozoan fauna in the hindgut of *Coptotermes formosanus* Shiraki (Isoptera: Rhinotermitidae), T. YOSHIMURA, K. TSUNODA and M. TAKAHASHI: *Jpn. J. Environ. Entomol. Zool.*, **6**(1), 31–35 (1994).

Effect of starvation on the protozoan fauna in the hindgut of the termite, *Coptotermes formosanus* Shiraki, was investigated. The largest protozoa in size, *Pseudotrichonympha grassii* Koidzumi, was the most sensitive to starvation, and no *P. grassii* was found after 3 days. The numbers of the middle-sized species, *Holomastigotoides hartmanni* Koidzumi, and the smallest species in size, *Spirotrichonympha leidyi* Koidzumi, were approximately one-fifth and one third compared with the original level after 5 days, respectively, and both species lived for longer than 2 weeks even though no food was available. The results supported the idea that each species had its inherent role in nutritional metabolism in the hindgut ecosystem.

Report of the 12th Congress of the International Union for the Study of Social Insects (IUSSI), T. YOSHIMURA: *Mokuzai Hozon (Wood Preservation)*, **21**(1), 23–27 (1995) (in Japanese).

Scientific documents relevent to termite research which were presented at the 12th Congress of IUSSI held at Paris, France, on 21–27 August, 1994 were outlined.

Biological resistance of wood chemically modified with non-formaldehyde cross-linking agents, S. YUSUF, Y. IMAMURA, M. TAKAHASHI and K. MINATO: *Mokuzai Gakkaishi*, **41,** 163–169 (1995).

Biological resistance of wood treated with non-formaldehyde cross-linking agents such as glyoxal, glutaraldehyde and dimethylol dihydroxy ethyleneurea (DMDHEU) were investigated.

Glutaraldehyde was most effective in eliminating the attack on Japanese cedar (*Cryptomeria japonica* D. Don) by a brown-rot fungus *Tyromyces palustris* (Berk et Curt.) Murr., a white-rot fungus *Coriolus versicolor* (L. ex Fr.) Quel., and the two subterranean termites of *Coptotermes formosanus* Shiraki and *Reticulitermes speratus* Kolbe. Decay by both fungi was almost nil in the treated cedar even at a more than 10% weight gain due to this agent. The complete death of both termites was attained also in glutaraldehyde-treated cedar at the same level of weight gain. DMDHEU treatment also was effective in enhancing the biological resistance of Japanese cedar. Enhancement of the biological resistance was recognized also in Japanese beech (*Fagus crenata* Bl.) treated with these agents, but it was somewhat less than in Japanese cedar. Such difference might be related to the values of the dimensional stability resulted from the treatments. Glyoxal treatment exhibited a poor

effect in improving the biological resistances and the dimensional stabilities of both wood species.

Property enhancement of albizzia waferboard by formaldehyde treatment, S. YUSUF, Y. IMAMURA, M. TAKAHASHI and K. MINATO: *Mokuzai Gakkaishi,* **41**, 223–228 (1995).

Low-density formaldehyde-treated waferboards were produced from a fast growing species of hardwood albizzia (*Paraserienthes falcata* Becker), and their mechanical, physical, and biodegradative properties were investigated. The vapor phase formalization was conducted at 120°C, employing tetraoxane as a vapor source of formaldehyde and sulfur dioxide as a catalyst. The values of weight gain (WG) and antiswelling efficiency (ASE) due to the treatment were not affected significantly by the reaction times of 5, 10, and 24 h. Modulus of rupture (MOR) decreased by the treatment for 5 h but was stable after longer treatment. Modulus of elasticity (MOE) scarcely decreased after the treatments. Internal bond (IB) strength increased with reaction times. This might have been caused by the effect of the formalization or by the catalyzing effect of the isocyanate resin used on the bonding characteristics. Formalization was found to have favorable effects in reducing the thickness swelling and linear expansion in water soaking, suggesting a strong stability by cross-linking formed against hot- and boiling-water. Biological tests revealed that formaldehyde-treated waferboards had a very great decay resistance even after the shortest 5 h treatment.

Weathering properties of chemically modified wood with some crosslonking agents, S. YUSUF, Y. IMAMURA, M. TAKAHASHI and K. MINATO: *Proc. 2nd Pacific Rim Bio-Based Composites Symp.,* Nov. 6–9, 1994, Vancouver, Canada, p. 160–168 (1994).

Spruce veneer (3 mm-thick) and 2-ply laminated veneer lumber (LVL) (2.5 mm-thick×2) of radiata pine were treated with cross-linking agents such as formaldehyde, glyoxal, glutaraldehyde, and dimethylol dihydroxy ethyleneurea (DMDHEU), under SO_2-catalysis. Resorcinol resin was used as an adhesive for LVLs. Film-forming transparent finish was applied to protect LVL from weathering. These wood samples were subjected to natural weathering (sunlight only and outdoor exposure) for 24 weeks or artificial weatheing (light and water) for a variety of exposure time. The effect of weathering was investigated mainly for color change and extent of checking. Reaction times in vapor phase formalization were inversely proportionate to the color change (Delta E) of spruce veneers exposed to sunlight until 12 weels, but not so significant after 24 weeks. Delta E of radiata pine LVLs was smallest in those with DMDHEU treatment, and largest in those with glutaraldehyde treatment after 24 weeks' outdoor exposure. In artificial weathering tests, all treated LVLs without finishes exhibited low Delta E values less than half of control samples for the whole 720 hours. In contrast, when treated samples were finished, they

showed larger Delta Es than those of control samples. However, checkings in all finished samples were significantly lesser than those of unfinished sampes. No significant difference was seen in overall checking resistance over treatments with cross-linking agents.

Properties enhancement of formaldehyde-treated aldizzia waferboard, S. YUSUF, Y. IMAMURA, M. TAKAHASHI and K. MINATO: *Proc. of the International Symposium on the Utilization of Fast-Growing Trees,* Nanjin, China, p. 207–216 (1994).

Low-density formaldehyde-treated waferboards were produced from a fast growing species of hardwood albizzia (*Paraserienthes falcata* Becker), and their mechanical, physical, and biological properties were investigated. The vapor phase formalization was conducted at 120°C, employing tetraoxane as a vapor source of formaldehyde and sulfur dioxide as catalyst. The values of weight gain (WG) and antiswelling effeciency (ASE) due to the treatment were not affected significantly by the reaction times among 5, 10 and 24 hrs. Modulus of rupture (MOR) decreased by the treatment for 5 hrs but was stable after longer treatments. Modulus of elasticity (MOE) scarcely decreased after the treatments. Internal bond strength (IB) increased with reaction times. This might be caused by the effect of formalization or catalyzing effect of isocyanate resin used on the bonding characteristic. Formalization was found to give a favorable effects in reducing the thickness swelling and linear expansion in water soaking, suggesting a strong stability of cross-linking formed against hot- and boiling-water. Biological tests revealed that formaldehyde-treated waferboards had a very high decay resistance even after the shortest 5 hrs treatment.

Wood preservative effectiveness of metallic naphthenates (2). Evaluation of various propertes of treated wood, M. SAKURAI and K. TSUNODA: *Mokuzai Hozon (Wood Preservation),* **20**(4), 189–194 (1994) (in Japanese with English summary).

Wood samples treated with metallic naphthenates were evaluated for their leachability, water absorption and hygroscopicity. Permeability of the chemicals into wood was also compared among three wood species.

Copper naphthenate showed a high resistance to leaching. Zinc naphthenate was inferior to copper naphthenate in leachability, especially at lower concentration.

Water absorption varied with wood species, although no conspicuous difference was found between the two test chemicals. Concerning the ratio of water absorption between treated and untreated woods, the highest value was recorded by *Pinus densiflora* and followed by *Fagus crenata* and *Cryptomeria japonica*. In the comparison of hygroscopic ratio, *P. densiflora* was the highest and followed by *C. japonica* and *F. crenata*.

Copper naphthenate afforded the tewated wood, have nothing to do with concentration 0.5–0.8 as hygroscopic ratios. Chemicals were easily permeated into *P. densiflora*. However, penatration of the chemicals into *C. japonica* and *F. crenata* was restricted only to the surface layers of wood. Apart from the effect of wood species, viscosity of the chemicals, which is

changeable with concentrations, appeared to influence the permeability.

Biological resistance of electrolessly plated wood (1). Preliminary report, M. HASEGAWA, K. TSUNODA and T. YOSHIMURA : *The Int. Res. Group on Wood Preserv.* Document No. IRG/WP 94–40034, pp. 5 (1994).

Surface metal coating is considered to improve biological resistance of wood as some metal ions are fungitoxic. Six wood species (three softwoods : *Cryptomeria japonica, Tsuga heterophylla,* and *Larix* spp. : three hardwoods : *Fagus crenata, Acer mono* and *Betula platyphylla*) were electrolessly plated with nickel or copper, and those were served for laboratory evaluation of their resistance against decay fungi *(Coriolus versicolor* and *Tyromyces palustris)* and subterranean termite *(Coptotermes formosanus).* On the basis of weight losses after 12 weeks' decay test, all the platedwood species proved resistant against *C. versicolor,* while none of the treatments could satisfactorily protect wood from decay by *T. palustris.* High termite resistance was produced in any case, and especially nickel-plated wood specimens caused 100% mortality of test termites within two weeks.

Acoustic properties of Brazilian rosewood used for guitar back plates, H. YANO, K. KYOU, Y. FURUTA and H. KAJITA : *Mokuzai Gakkaishi,* **41**(1), 17–24 (1995).

The acoutic properties of Brazilian rosewood *(Dalbergia nigra)* used for guitar back plates were evaluated by the free-free vibration method at 20°C and 65% R.H. (relative humidity). After comparing the acoustic properties with those of Indian rosewood *(D. latifolia)* used for the guitar back plate, German spruce *(Picea abies)* and western red-cedar *(Thuja plicata)* used for the guitar top plate, the acoustic characteristics of Brazilian rosewood were investigated from the viewpoint of the effects of methanol extractives.

The specific gravity of Brazilian rosewood was about 1.1, 2, and 2.5 times that of Indian rosewood, German spruce, and western red-cedar, respectively. The difference between Brazilian rosewood and Indian rosewood also was observed in the value of tan δ in the longitudinal direction, and the mean value of Brazilian rosewood was less than that of Indian rosewood by 20%. In comparison with the German spruce for the guitar top plate, the mean value of specific dynamic Young's modulus in the longituginal direction was 30% less, while the values of tan δ in the longitudinal direction and in the direction perpendicular to the longitudinal direction were 15% and 20% less, respectively, which is opposite of the relationship found between German spruce and maple (*Acer* spp.) used for the violon top plate and back plate, respectively.

Due to methanol extraction, the oven-dry weight of Brazilian rosewood was reduced by up to 30% and the value of tan δ in the longitudinal direction as well as in the direction perpendicular to the longitudinal direction increased linearly by up to 120% with reduction in the oven-dry weight. The acoustic properties of Brazilian rosewood are affected strongly by the methanol extractives.

Tunneling of subterranean termites, *Coptotermes gestroi* Wasmann and *Ceptotermes formosanus* Shiraki, into gravel physical barriers, Y. SORNNUWAT, C. VONGKALUANG, T. YOSHIMURA, K. TSUNODA and M. TAKAHASHI: *Jpn. J. Environ. Entomol. Zool.*, **7**(1), 13–19 (1995).

Tunneling into graval barriers was investigated in the laboratory using two economically important termite species, *Coptotermes gestori* Wasmann from Thailand and *Ceptotermes formosanus* Shiraki from Japan. Particles from 1.4 to 2.4 mm in diameter could prevent *C. gestroi* from tunneling and gravel particles of 1.7–2.4 mm were effective against *C. formosanus*. Additional field evaluation strongly supported the laboratory results for *C. gestroi*. Particles of 1.2–1.7 mm and 1.7–2.4 mm performed well after 12 months' testing. It seems worthwhile to discuss practical methods to use gravels, cost effectiveness, and related matters for future commercialization in both Thailand and Japan.

Production and ptoperties of composite fiberboard I. Influence of mixing ratio of jute/wood fiber on the properties of boards, M. ZHANG, S. KAWAI and H. SASAKI: *Mokuzai Gakkaishi,* **40**(8), 816–823 (1994) (in Japanese with English summary).

The lengths and diameters of hardwood and jute fibers were measured by using an image analysis system. The shapes and the ratios of fiber lengths to diameters are discussed. The tensile strengths of the fibers measured. The lengths, diameters, and tensile strengths of hardwood fibers are 1/6, 7/2 and 1/5 times, respectively, those of jute fibers.

Both fibers were mixed thoroughly with jute/wood mixing ratios (J/W) of 1/0, 3/1, 1/1, 1/3, and 0/1. Using these mixed fibers, composite boards with four different specific gravities (SG) were produced. Moduli of rupture (MOR) and moduli of elasticity (MOE) in both dry and wet conditions, internal bond strength (IB), thickness swelling (TS), and linear expansion (LE) were determined and examined. These properties were influenced by the J/Ws and SGs of boards. MOR, MOE, and dimensional stabilities in the plane increased with increasing mixing ratios, and IB and TS had minimum values at the ratio of 3/1.

Isocyanate-inorganic bonded composites III. Rapid production of cement-bonded particleboard by steam injection pressing, D.A. EUSEBIO, S. KAWAI, Y. IMAMURA, and H. SASAKI: *Mokuzai Gakkaishi,* **40**(9), 922–930 (1994) (in Engilish summary).

Isocyanate cement-vonded particleboards were produced with the introduction of steam injection pressing (SIP). The effects of SIP conditions, total pressing time (TPT), isocyanate (IC) resin content, and water content (WC) on board properties were determined. The optimum steam pressure and injection time were 1.25 kgf/cm^2 and 3 secs, respectively. The maximum bending moment and bending rigidity were independent of

the TPT, whereas the moduli of rupture and elasticity increased as the TPT was increased. Maximum internal bond strength was obtained at 10 min of TPT with 12% IC resin and 50% WC. Longer TPT resulted in less water absorption. Boards with 12% IC resin content had better properties than those with 8% IC resin content. Increasing the WC decreased the strength ptoperties of the boards but this depended on the TPT. Scanning electron microscope observations revealed that cement crystallization was not affected adversely by SIP.

Recent trials on utilization of fast-growing plants, H. SASAKI, S. KAWAI and L. MA : *Proc. of the Intern'l Symposium on the Utilization of Fast-Growing Trees,* ed. C. Chao, H. Sasaki and Y. Hua, p. 162–170, Oct. 15–18, Nanjung China (1994).

In these five years, developmental research works on the utilization of fastgrowing plants such as several wood species growing in the tropical plantation forests, thinning from domestic cedar plantation forests, domestic bamboo and imported sugar canes have been conducted extensively by a research group on structural composites in the Wood Research Institute Kyoto University. The present paper reviews the topics in the research works. Those are as follows:

1) The main species investigated in the present paper are *Acacia Mangium* (AM), *Eucalyptus deglupta* (ED), *Gmelina arborea* (GA), *Paraserianthes falcataria* (PF) and *Eucalyptus urophylla* (EU). These species are growing very quickly and the cutting age is estimated at around ten years for the production of pulp and paper and of MDF in future. The present states of plantation of fast-growing wood species in the South-East Asian countries have been investigated. The mechanical properties of sawn lumbers and 9-ply LVL cut and manufactured from the same resources were compared. The experment reviled the applicability of these LVL to the structural use.

2) In Japan, there are around 10 million hectares of plantation, and half of this is for *Cryptomeria japonica.* Developmental research for the efficient utilization of this species is important for Japanese forest. The species has an excellent ratio of fiber-directional strength per density. To emphasize its structural application, methods for manufacturing tubular LVL poles have been developed. A continuous molding press with RF-heating facilities was employed with tongue-and-groove type edge joints to assemble into a tubular LVL pole with 30 cm diameter and 35 mm thickness. The tubular LVL had enhanced the mechanical properties when filled inside with urethane foam. However this method seems to be impractical because it is too complicated.

3) A new method that is similar to the manufacture of paper tubes was employed to improve the productivity. The method required helical winding of veneer tapes with lateral grain reinforced by papers or special textiles. Compressive forces and a torque for rotating the tube around a mandrill were applied through driving belt. This new method was

supposed to be promising.

4) Bamboo and bagasse are useful resources with a recycle system. However these materials contain chemical inhibitors for curing cement mortar when used as raw materials for the production of cement-bonded particleboards. A new method to eliminate this inhibitory effect was developed. This was done by mixing cement with sodium hydrogen carbonate and introducing steam-injection pressing technology. The properties of bamboo cement boards are discussed.

Production and properties of bamboo/wood compsoite fiberboard, M. ZHANG, S. KAWAI and H. SASAKI: *Proc. of the Intern'l Symposium on the Utilization of Fast-Growing Trees,* ed. C. Chao, H. Sasaki and Y. Hua, p. 270–279, Oct. 15 –18, Nanjing, China (1994).

An image analysis system was used to measure the sizes and shapes of natural fiber bundls such as jute, bamboo, hardwood, softwood and lint, and other fibers such as polyester and glass fobers for the comparison. The tensile strength of the fibers were then measured. Jute/wood and bamboo/wood composite fiberboards were manufactured by using jute, bamboo and wood fibers as raw materials at various fiber mixing ratios. Fiber drying device and adhesive blender integrated in one machine, and fiber mat forming device in laboratory-scale were fabricated and used to manufacture the different composite fiberboard.

Experimental results for tensile test of each kind of fibers revealed that in natural fibers the tensile strength and the Young's modulus of jute fiber is strongest. The specific tensile strength and specific Young's modulus of jute and bamboo fibers are 1.7 to 2.5 times larger than hardwood fibers,

The properties of the composite fiberboards produced were tested and evaluated. Modulus of rupture (MOR) of jute/wood composite fiberboard increased with increasing jute fiber to wood fiber mixing ratios, and internal bond strength (IB) had minimum values at the ratio of 3/1.

Adding bamboo fibers into the wood fibers at different ratios improves the waterproof property of bamboo/wood composite fiberboard. The retention ratio of MOR after boiling increased by 5% to 15% . Also, the linear expansion (LE) of the composite fiberboard is reduced by 5 to 10 times.

Rapid curing of cement-bonded particleboard with sodium hydrogen carbonate and steam injection pressing technology, D.A. EUSEBIO, S. KAWAI, H. SASAKI, Y. KUROKI and W. NAGADOMI: *Proc. of the Intern'l Symposium on the Utilization of Fast-Growing Trees,* ed. C. Chao, H. Sasaki and Y. Hua, p. 130–138, Oct. 15–18, Nanjing, China (1994).

This paper discusses some of the experimental researches conducted on how to shorten the pressing time of cement-bonded particliboard (CBP) with the introduction of steam injection pressing (SIP). Series of experiments was done by incorporating isocyanate (IC)

resin or by the addition of sodium hydrogen carbonate ($NaHCO_3$) to cement as binder.For CBPs with IC resin or isocyanate-cement bonded particleboard (IC-CBP) as termed here, the effects of varying the total pressing time (TPT) on board properties, at defferent IC resin content and water content (WC) were determined. The second part will delve on the addition of $NaHCO_3$ and the properties of the boards as affected by varying the amount of $NaHCO_3$, TPTs, and steam injection time (SLT) will be discussed.

For IC-CBPs, the optimum steam pressure and SIT were 1.25 kgf/cm^2 and 3 secs., respectively. The maximum bending moment and bending regidity were independent of the TPT, whereas the moduli of rupture (MOR) and elasticity (MOE) increased as the TPT was increased. The naximum internal bond (IB) strength was obtained at 10 min of TPT with 12% IC resin and 50% WC. TS values were smaller at shorter TPTs except for boards with 12% IC resin content and 50% WC while the WA property decreased with increasing TPT.

In the case of CBPs with $NaHCO_3$, the steam pressure applied was 2.5 kgf/cm^2 while the SIT was varied from 0.5, 1, 2, 3, and 5 secs. The maximum MOR and MOE were obtained on CBPs with $NaHCO_3$ of 20% and at SIT of 2 secs. Test results indicated a general tendency in strength to improve with increasing TPT. The values obtained here were significantly small compared to those boards with IC resin.

In these series of experiments, it revealed that the boards could be handled immediately after pressing when IC resin was incorporated or $NaHCO_3$ was added to cement as binder and with the application of SIP.

Steam-injection presing in wood composites production, H. SASAKI, S. KAWAI, K. UMEMURA, D.A. EUSEBIO and Y. KUROKI: *Proc. of the Second Pacific Rim Bio-Based Composite Symposium,* p. 9–16, Nov. 6–9, Vancouver (1994).

In the past five years, great advancement has been made in the Wood Research Institute, Kyoto University on the manufacturing technology of wood composites with steam-injection pressing. Some of the significant accomplishments are as follows:

1. Chemical decomposition in lignin components and the capricious rebonding between the fractions with a high-pressure steam treatment (explosion) were verified. The increase in the crystallization of cellulose were also observed with the process. Pernanent set of compressive deformation in the lateral direction of wood were performed with a sealed hot-pressing. This permanent set would be attributed to the above chemical behaviors of wood components.

2. Simultaneous polymerization and decomposition of adhesive resins were observed during high-pressure steam processing. Special techniques were used to stop the chemical reaction of the resins, that is, steam filling in a reaction cell was replaced immediately with liquid nitrogen at different steaming times. The physical and chemical changes of the

adhesive resins were clarified with functions of steam-injection time and the temperature (steam pressure).

3. The above information with the permanent set of wood deformation and the behavior of adhesive resins during the process of high-pressure steam-injection were utilized to manufacture highly stabilized wood composites.

4. Two types of continuous presses with steam-injection functions were developed. One is an intermittent type of press with steam-injection functions from top and bottom perforated platens and a cold tapered inlet. The other is a continuous steel belt running press with steam-injection functions from both sides of the press. The foumer is suitable for manufacturing thick and low density semi-flake particleboards. The latter would be useful to manufacture veneer/particle composite beams and also laminated veneer lumbers.

5. The steam-injection pressing technologh has been applied for the rapid -hardening of cement-bonded particleboards. Carbonate compounds were mixed with other materials to generate carbon dioxide during steam-injection pressing. The wood-cement mat hardened within a second of steam injection and a few minutes of hot-pressing with a seal system. However, the furnish hardened with the abrupt formation of calcium carbonate and calcium silicate. Cement hydration may have not taken place at this stage. This resulted to boards with significantly low strength properties. Discussion will be elaborated on methods of improving the hydration of cement.

Recent development of Japanese research on composite wood, H. SASAKI and S. KAWAI: *Wood Science and Technology,* **28**, 241–248 (1994).

This paper highlights a number of articles on research and development on wood composites. The coefficient of variation in the mechanical properties of wood components tends to decrease when the thickess of the wood elements decreases. This finding was utilized in the manufacture of hollow cylindrical columns of laminated veneer lumber (LVL) from *Cryptomeria* plantation thinnings. In the future, the marketing of wood composite boards will tend toward two types: thick boards with low density properties and thin boards with fiber orientation. For the production of thick boards, fundamental parameters and application of steam-injection pressing have been studied, and continuous steam-injection pressing has been developed. For thin board production, generation principles of aligning torque in high-voltage system and the application has been studied. A new oriented mat fromer with electrodes positioned only at the reverse side of a forming belt has been developed. Various synthetic resins of low-molecular weight have been applied to improve dimensional stability of laminated products, such as LVLs and particleboards. Acetylation and formalyzation of fibers and particles were investigated to provide stabilized panels. High pressure steam treatment during prssing of wood composites has been studied and the process has been dound effective and promising.

Curing behaviour of wood adhesives under high steam pressure, K. UMEMURA, S. KAWAI. H. SASAKI and R. HAMADA: *Abstract Book of the International Adhesion Symposium,* p. 155–157, Nov. 6–10, Yokohama (1994).

Steam-injection pressing is a recent development for manufacturing wood products. The curing mechanism and behavior of wood adhesives during steam-injection heating and hot-platen heating may cause differences in both chemical and physical aspects. The curing of wood adhesives under high steam pressure using an especially designed reaction cell was discussed. The adhesives used in this study were phenol-formaldehyde (PF), urea-formaldehyde (UF), melamine-formaldehyde (MF), and isocyanate (IC) resins. At different curing time, the heating temperature (steam pressure) applied to cure the adhesives were 160°C (6 kgf/cm^2). Results were examined by analytical methods using FT-IR, ^{13}C-NMR, dynamic mechanical analysis and solvent extraction. (1) By steam-injection heating, PF resin immediately cured to some degree in a few minutes and maintained an equilibrium situation. In this case, the reaction was accompanied by the disappearance of ether stucture. (2) In UF resin, results from IR data clarified different reactions between hot-platen heating and steam-injection heating. By steam-injection heating, as heating time increased, UF resin returned back to its liquid state by the infuence of hydrolysis. (3) MF resin almost cured under steam-injection in a short heating time compared with hot-platen heating. (4) IC resin foamed and cured in a short heating time under steam-injection. It was proved that steam-injection heating was more effective than by hot-platen heating for IC resin.

Availability of zephyr-mat made from Sugi rotary-veneer (II). Field test of weed-proof and vegetation zephyr-mat, K. NAKATA, H. SUGIMOTO, H. KAIMOTO and S. KAWAI: *Mokuzai Kogyou (Wood Industry),* **50**(1), 13–17 (1995) (in Japanese with English summary).

Three types of zephyr-mats were made from rotary-cut veneers of Japanese ceder thinnings. The adaptability of zephyr-mats was determined for the use of the weed-proof mats and the vegetation mats.

The manufacturing process and the types of zephyr-mats were the same as the previous report. The results were as follows:

1) For the field-test of the weed-proof mats taped by the hot melt adhesive or shading-nets glued by the synthetic rubber adhesive were spread around the nursery stocks in the forest. The durability of the former was inferior because the adhesive and zephyrs were broken in an early stage, while the weed-proofness of the latter and its durability sdfd superior. Then, zephyr-mats of 3 mm thickness were durable and easy spreading.

2) For the seed germination test of the vegetation mate, zephyr-mats glued with papers contained grass-seeds were spread in the greenhouse. For the zephyr-mats whose shadiness

rate was less than 96%, the germination of the seeds were superior. Then, as the crushing time was increased when zephyr was made, the zephyr mats were found to become flexible.

Relationship between tensile strength of natural fibers and their sizes, M. ZHANG, Y. KISHIMOTO, S. KAWAI and H. SASAKI: *Wood Research and Technical Notes,* No. **30**, 32–39 (1994) (in Japanese with English summary).

An image analysis system was used to measure the sizes and shapes of natural fiber bundles such as jute, hardwood, softwood, bamboo and lint, and other fibers such as polyester and glass fibers for the comparison. Fibers were magnified through the microscope and the picture of the fibers was input the image analyze system to measure the length and diameter of the fiber. The ratio of fiber length to diameter was then calculated.

The mosture content of each kind of fiber was determined. The tensile strength of the fibers were then meaured. Based on the experimental results, the mechanical properties and the configuration of the fibers were compared with each other, and the characteristics were disussed.

Experimental results revealed that in natural fibers the tensile strength decreases gradually with increasing fiber length, but the tensile strength and the Young's modulus in tension decrease remarkably with increasing natural fiber diameter.

Rapid curing of cement-bonded particleboard I. Steam injection pressing of cement-bonded particleboard with sodium hydrogen carbonate, D.A. EUSEBIO, Y. KUROKI, W. NAGADOMI, S. KAWAI and H. SASAKI: *Mokuzai Gakkaishi,* **41**(3), 309–317 (1995).

To shorten the pressing time of cement bonded particleboard (CBP), a series of experiments was conducted. This was done by incorporating sodium hydrogen carbonate ($NaHCO_3$) into ordinary portland cement (OPC) as a binder and applying steam injection pressing. The optimum steam injection pressure was determined, and the effects of varying the steam injection time (SIT), the amout of $NaHCO_3$ and the total pressing time (TPT) on the properties of boards were evaluated. Several curing and conditioning methods such as 3 and 7 days of polyvinyledene chloride film wrapping as well as water immersion for different time intervals were done to enhance board properties. In addition, the possibility of using wood species which contain extractives detrimental to cement setting was clarified. Considering the scope of the experimental conditions covered here, results revealed that the initial hardening of cement can be achieved within 2 sec and 3 min of SIT and TPT, repectively, with at least a 5% $NaHCO_3$ addition, and that the CBP could be handled immediately after pressing.

Production of laminated veneer lumber with a continuous steam-injection press I. Selection of steam permeable materials and production of laminated veneer lumber, Y. YANAGAWA, S. KAWAI, H. SASAKI, Q. WANG, M. KONDO and F. SHIRAI: *Mokuzai*

Gakkaishi, **41**(5), 474–482 (1995) (in Japanese with English summary).

This report deals with the development of the technology of producing laminated veneer lumber (LVL) with a continuous steam-injection press. Steam permeable materals to be penetrated by high-pressure steam were investigated, and sugi (*Cryptomeria Japonica* D. Don) LVL was produced using such materials which can be used in the production of LVL on an industrial scale.

The results are summarized as follows:

1) To inject steam between veneers, ① corrugated cardboard, ② corrugated cardboard without one surface, ③ veneer strips, ④ glass-fiber net, ⑤ organic fiber net, and ⑥ corrugated veneer were used. These materials were incorporated between veneers of LVL, and ateam was injected from one side. As a result, these materials absorbed steam, and the temperature between veneers reached 100°C after a few seconds of steam injection. From the viewpoint of lessening production cost and not lessening the strength of the LVL, corrugated veneer was the most suitable for the production of LVL.

2) In the production of LVL with a continuous steam-injection press, corrugation of the veneers disappeared after the pressing, and no delaminations appeared between veneers.

3) Bending and bending-shear tests were conducted in accordance with Japanese Agricultural Standard (JAS) for Structural Laminated Veneer Lumber. The quality of the produced LVL using corrugated veneers met the JAS requiements.

Production of laminated veneer lumber with a continuous steam-injection press II. Production and properties of fiber reinforced laminated veneer lumber, Y. YANAGAWA, S. KAWAI, H. SASAKI, Q. WANG, M. KONDO and F. SHIRAI: *Mokuzai Gakkaishi,* **41**(5), 483–489 (1995) (in Japanese with English summary).

Gkass-fiber net (net) reinforced sugi (*Cryptomeria japonica* D. Don) laminated veneer lumber (LVL) was manufactured by a continuous press with steam-injection heating devices on both sides. Properties of these LVL were examined.

The results are summarized as follows:

1) From a side view of fiber-reinforced LVL, produced with a steam-injection press with a pressing time of 5–10 minutes, it was seen that net was incprporated into the veneer, and there were no delaminations between veneers.

2) Flexural strength of the fiber-reinforced LVL was more than that of the control LVL in flatwise benbing. In edgewise bending, the number of nets increased, and the flexural strength increased. The modulus of elasticity (MOE) did not increase remarkably with the incorporation of the net into the LVL.

3) In the flatwise horizontal-shear test, the shear strength of the fiber-reinforced LVL was almost equivalent to that of the control LVL. The average shear strength in flatwise loading after cyclic boiling (4 hr boil, 20 hr drying, then 4 hr boil) was about 70% of that of

LVL in an air-dry condition. In the edgewise horizontal-shear test, all specimens ruptured on the tension sides, and shear strength increased with increasing numbers of nets.

4) The splitting strength of fiber-reinforced LVL increased proportionally with incresing numbers of nets, and fiber-reinforced LVL persistently fractured.

5) With a creep test under fire, the fire endurance properties of fiber-reinforced LVL improved remarkably with increasing numbers of nets.

Production of laminated veneer lumber with a continuous steam-injection press, S. KAWAI, H. SASAKI, Q. WANG, Y. YANAGAWA, M. KONDO and F. SHIRAI: *Proc. of the Intern'l Symposium in the Utilization of Fast-Growing Trees,* ed. C. Chao, H. Sasaki and Y. Hua, p. 589–596, Oct. 15–18, Nanjing, China (1994).

A continuous press with steam-injection functions installed on both sides near the feeding section was developed. The application of this press to the continuous production of thick laminated veneer lumber (LVL) requires a uniform penetration of high-pressure steam throughout the stacked veneers.

Thus, sheet of materials were used to penetrate steam among veneers and the temperature was investigated by monitoring the behavior through the plane direction of the LVL when high-pressure steam was injected. The temperature rising curves proved that corrugated cardboard, glass-fiber net, composed veneer strips, and corrugated veneer set in a hot-press were applicable for steam penetration. The veneer corrugation disappeared after steam-injection pressing due to the recovery of the set.

The raw materials used were 3.0 mm thick veneers from thinnings of sugi (*Cryptmeria japonica* D. Don). Non-corrugated veneers were spread with isocyanate or resorcino formaldehyde adhesives on both faces and were stacked alternately with corrugated veneers to produce a 19-ply LVL. Two sets of LVL (19+19-ply), each with a length, width, and thickness of 1,200, 300 and 50 mm respectively, were pressed in the continuous steam-injection press simultaneously. The steam- and pressing pressure applied were 6 kgf/cm^2 (160°C) and 10 kgf/cm^2, resectively. The practical pressing time was around 8–10 minutes.

The flexural properties on both flatwise and edgewise bending, the shear strength of short-span bending in both dry and wet conditions, and the cleavage strength of the LVL were examined in accordance with Japanese Agricultural Standard (JAS) for strucutal LVL. Thests revealed that the quality of the LVL passed the JAS standards for structural purposes.

These results showed that thick LVL could be produced bv a continuous process using the newly developed continuous steam-injection press with a very short pressing cycle.

Conversion of preservative-treated recycled wood into particleboard, H. KAJITA, S. KAWAI and S. KASHIWAZAKI: "Recyling and Safe-Disposal Technology of Preservative-Treated Wood" ed. by The Japan Wood Preservation Association, p. 17–30 (1994) (in

Japanese).

CCA-treated and creosote treated recycled wood was converted into particleboard bonded with various adhesive resins. The preservatives affected neither the bondability of the resins nor the properties of particleborad. The particleboards made from creosote treated recycled wood performed high-resistance against decay fungi and termites. The particleboards from CCA treated recycled wood showed high resistance agajnst termites, but did not show sufficiently high performance against decay fungi.

Conversion of preservative-treated recycled wood into pulp and paper, M. AYAKI and S. KAWAI: "Recycling and Safe-Disposal Technology of Preservative-Treated Wood" ed. by The Japan Wood Preservation Association, p. 39–46 (1994) (in Japanese).

This study aims at investigating the pollution of the wood preservatives from CCA-treated or creosote treated recycled wood chips under the alkali pulping process. The results showed that in the case of CCA treated recycled wood chips, Cu remained mainly in the unbreached pulp, while Cr and As in the recovered kraft waste liquor. It was estimated that about 50% of each component of the preservative was remained in the rinsed water. In the case of creosote treated recycled wood chips, creosote remained mainly in the unbreached pulp. Therefore, appropriate counterplans are necessary in the processes of recovery of waste karft liquor and recovery of rinsed water, and the utilization of the pulp, when such preservative treated wood chips were mixed in.

The elements of wood composite products, S. KAWAI: The Textbook of the Seminar of Practical Knowledge in Wood ed. The Japan Wood Technological Association, p. 55–64 (1994) (in Japanese).

The elements of wood composite products and their production technology were outlined. The recent development of composite wood was introduced.

Changing the wood waste into resources, S. KAWAI: "Wood and Environment" ed. by M. Kuwahara, p. 121–132, Kaisei-sha (1994) (in Japanese).

The present condition of recycling wood from scrapped houses was reviewed and the sepqration process of wood chips from other residues was explained.

Bending strength of Glulam using graded Spruce-Pine-Fir, S. TAKINO and N. ANDO: *Proc. of the Intern'l Symposium in the Utilization of Fast-Growing Trees,* October 15–17, 1994, Nanjing, P.R. China, C. Chison, H. Sasaki and H. Yukun, eds., p. 171–175, China Forestry Publishing House, Beijing (1995).

Glulams laminated utilizing the lumbers (Canadian secondary standard Spruce -Pine-Fir, nominal cross section size 30 mm×87 mm) selected according to their bending stiffness and defective areas were manufactured and were tested of their bending stiffness and strength. After that, the EI values were caluculated using lamina's bending stiffness and

strength. The EI_t (tested value) were 80%–94% of EI_c (caluculated value). As a result of the caluculated EI values for great number of laminas, Glulam's EI values were estimated. The bending strength of Glulam were estimated using the relationship between the tested bending stiffness and strength.